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PATENT SPECIFICATION 910,894

DRAWINGS ATTACHED.

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Date of filing Complete Specification (under Section 3(3) of the Patents Act, 1949): April 27, 1961.

Application Date: April 27, 1960. No. 14759/60.
Application Date: July 19, 1960. No. 25125/60.

Complete Specification Published: Nov. 21, 1962.

Index at Acceptance:—Class 7(3), B2J22.
International Classification:—F02L

COMPLETE SPECIFICATION.

Improvements in and relating to Apparatus for Testing the Injectors of Compression Ignition Internal Combustion Engines.

We, LESLIE HARTRIDGE LIMITED, a British Company, of Tingewick Road, Buckingham, Buckinghamshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to testing apparatus for the injection nozzles of compression ignition internal combustion engines. Such apparatus normally comprises a manually operated pump by which liquid (usually fuel oil of the type used in the engines) is compressed and supplied through a duct to the injector to be tested, there being a pressure gauge connected to the injector to indicate the pressure at which the injector needle lifts to open the injector.

The conventional injector used in internal combustion engines comprises a body adapted to be mounted in the engine having an injection nozzle mounted at its end, the latter penetrating into the engine cylinder. The nozzle consists of a nozzle body containing a valve seat and one or more orifices through which the fuel is injected, and a needle having a conical valve portion which seats itself on the seating formed in the nozzle body. In use the needle is acted upon by a powerful spring which keeps it in position on the seating. When pressure is applied to the nozzle it acts on the portion of the valve cone above the seating and when the pressure rises above a predetermined level it lifts the needle, whereupon some of the fuel oil is forced past the seat and through the injection orifice or orifices. This lowers the pressure in the nozzle body and the needle tends to seat again. If the pressure is maintained at a high level (as when the pump piston is moving at high speed) then the needle is held open and the pressure is governed by the restriction imposed by the injection orifices, but if the pump piston is moving slowly then the escape of fuel allows the needle to fall back upon the seat, when the pressure again rises to lift the needle. The injector thus opens and closes very rapidly, and makes a buzzing noise. A good injector should "buzz" well.

In testing and setting nozzles information is required on four points, some of which are inter-related. The first is whether the needle makes a fluid-tight joint with the seating or whether it is leaky; the second is the amount of leakage between the needle diameter and the bore in the nozzle body in which it is located; the third is whether it will "buzz" well (a leaky nozzle will not "buzz" very well); and the fourth is the fuel pressure at which it will open. Information on the first point may be obtained by subjecting the nozzle to a fuel pressure just below that at which it will open, for a short period. If the seating is leaky then a droplet of fuel collects on the end of the nozzle. If such leakage takes place while the injector is operating in the engine the fuel which leaks is converted to carbon so that a thick deposit of carbon quickly builds up on the nozzle body and this interferes with the efficient operation of the engine. Assuming that the needle makes a fluid-tight joint on the seating, the leakage along the needle diameter may also be determined by applying a pressure just below the needle opening pressure to the nozzle body and then holding the pump piston still. The rate at

[*Price 4s. 6d.*]

which the pressure in the system leaks away is a measure of the leakage along the needle diameter but since some fuel may also leak past the pump the test is not reliable in the known apparatus. If the leakage in the nozzle body is excessive then, in normal operation, the rate of pressure rise at each injection is slower than it should be and this again interferes with the satisfactory operation of the engine.

The "buzz" test is carried out by operating the pump very slowly so that the injector needle is allowed to re-seat itself after each ejaculation of fuel oil. In the known apparatus the rapid fluctuations in pressure at the injector cause jerky movement of the pump lever.

The setting of the opening pressure is carried out by operating the pump extremely slowly, so that the pressure is gradually raised to the injector opening pressure, and noting the reading on the pressure gauge at which the needle lifts to allow an injection of fuel. It is most important that the pump should be operated slowly, and even so there is difficulty in noting the pressure reading because, as already mentioned, the pressure drops as soon as the needle opens. If the pump lever is operated a little too quickly then the pressure rises too rapidly to the opening pressure and the pressure gauge needle flies back and "judders" before the operator has been able to note its reading, so that he is left in doubt as to the exact pressure at which the nozzle opened.

The above disadvantages of the known apparatus are caused by changes in volume of liquid in the duct due to rapid and intermittent loss of liquid from the injector changing the pressure in the said duct with the result that the flow rate of the liquid entering the duct is substantially influenced and corresponds with the fluctuating demand of the injector causing an uncontrollable and erratic movement of the pump operating lever and the subsequent erratic functioning of the injector.

A further disadvantage of the known apparatus is that when an injector leakage or back-leakage test is made leakage if present at the pump introduces a factor which gives rise to an erroneous result.

The principal object of the present invention is to provide apparatus of the type first set forth herein wherein the said disadvantages are eliminated in a particularly simple manner.

A further object of the present invention is to provide apparatus in which the above-mentioned tests may be carried out with certainty by a relatively unskilled operator.

The invention, according to one aspect thereof, resides in the provision in apparatus for testing injectors and injector nozzles of compression ignition internal combustion engines, said apparatus comprising a manually operable pump adapted to supply liquid under pressure through a duct to an injector to be tested, there being a pressure gauge connected to the duct to indicate the pressure applied to the injector, of an adjustable liquid-flow restrictor valve provided in a passage leading from the pump to the duct.

The invention also resides in apparatus for testing injectors and injector nozzles of compression ignition internal combustion engines comprising a manually operable pump, a pressure gauge, means to support an injector and nozzle to be tested, and two adjustable restrictor valves, one of the restrictor valves being connected between the pump and the injector nozzle and the other of the restrictor valves being connected between the injector nozzle and the pressure gauge.

The invention includes apparatus comprising a base, a hand-operated pump mounted in the base, a casing on the base, a pressure gauge mounted on the casing, two manually operable restrictor valves in a valve block supported on the casing, a support for an injector and nozzle to be tested carried on the casing, a duct in the block communicating with one side of each of the restrictor valves, a pipe connecting the duct to the injector, a pipe connecting the pump to the other side of one of the restrictor valves, and a further pipe connecting the pressure gauge to the other side of the other of the restrictor valves.

In operation the restrictor valve is adjusted so that it greatly restricts the passage communicating with the said duct so that pressure variations in the said duct inherent in the functioning of the injector do not substantially influence the rate of flow passing through the restrictor valve or effect the movement of the pump operating lever. This enables the operator to control the rate of flow to suit the injector to be tested and the particular test to be carried out.

One form of apparatus according to the invention will now be described with reference to the accompanying drawings in which:—

Figure 1 is a front elevation of the injector tester;

Figure 2 is a sectional side elevation of the tester;

Figure 3 is a plan view of the tester;

Figure 4 is an enlarged "ghosted" view of the control valve block in the tester; and

Figure 5 is a side view of an injector support bracket showing an injector in position.

Referring to the drawings, the tester comprises a base 11, provided with lugs 12 by which it may be fixed to a bench, and a casing 13 forming a superstructure on which the controls, instruments and a hood for the

injector nozzle under test are mounted. Contained in the base 11 is a high pressure pump comprising a cylinder 14, suitably attached to the base, co-operating with a piston 15 which is urged by a spring 16 to its outer position. The piston 15 has an extension 17 which is acted upon by an arm 18 of a bell crank, the other arm 19 of which has a lever 20 attached to it, terminating in a ball end 21. The bell crank is pivoted on a pin 22 supported in lugs 23 and 24 which are integral with the base 11. The bell crank has a third arm 25 having a flat end which engages a face 26 on the base 11, the engagement limiting the outward movement of the piston 15 under the influence of the spring 16. The outlet 27 of the pump is connected by a pipe 28 to a block 29 which is shown in more detail in Figure 4 and will be more particularly described hereinafter. For the present it will suffice to mention that fuel pumped through the pipe 28 passes through a first restrictor valve to an outlet from the block 29, and thence to the injector under test by a pipe 30. The injector is supported on a bracket (not shown in Figures 1, 2 or 3 but shown separately in Figure 5) bolted to facings 55 on the base. The injector is surrounded by a hood 31 to prevent the injector spray from being distributed over a large area. At the rear of the hood 31 is an extractor fan 56 to remove the spray and since the finely divided spray, intimately mixed with air, is highly inflammable the extractor fan is preferably driven by an air-turbine 57 because an electric motor might produce sparks. The turbine 57 is supplied with compressed air through a pipe 58 and is controlled by means of a control valve 65 mounted on the casing 13. The extractor, being of a centrifucal type also acts to condense the fuel oil, which is then returned through a pipe (not shown) to a reservoir 59 built into the base, from which it is supplied to the pump cylinder 14 through a duct 60. The reservoir is initially filled through a filler cap 61.

Fuel supplied to the block 29, after passing through the first restrictor valve, may also pass through a second restrictor valve and into a pipe 32, which leads to a pressure gauge 33 mounted on the superstructure 13. The hood 31 includes an upper domed portion 34 containing a lamp, controlled by a switch 35, which may be switched on when desired in order to obtain a better view of the spray or any droplets which may form at the nozzle end during the seat leakage or "dry seat" test.

Above the pressure gauge 33 is a stop clock 36 which may be started and stopped by a lever 37 and set to zero by means of a button 38. The stop clock enables the time required for the pressure to fall from one level to another (leakage test), or the time during which pressure is maintained, to be accurately determined.

The control block 29 previously referred to comprises, as shown in Figure 4, an inlet connection by which fuel oil from the pump may be supplied via the pipe 28 to a needle type restrictor valve 39, co-operating with a seating 40. The needle valve is connected to a screw-threaded stem 41 having a knob 42 at its end, the screw-threaded stem passing through a nut 43 attached to the block 29. A pointer 44 is attached to the knob 42 and co-operates with a graduated scale 45 (Figure 1) by which the setting of the needle valve 39 may be determined.

Fuel oil passing through the needle valve 39 enters a duct 46 in the block 29 which communicates with the pipe 30 leading to the injector. The pipe 30 is held in position on the block 29 by a fitting 47, and its other end is connected to a fitting 62 which passes through the casing 13. A further pipe 66 (Figure 5) is connected between the last-mentioned fitting and the injector on test. The bracket fitted to the facings 55 and the pipe connection to the injector must, of course, be suited to the particular injector being tested and several types may be necessary to cover all the different kinds of injector which may require testing. A typical bracket is shown in side view in Figure 5 and consists of a base portion 67 and a support portion 68 which carries a plate of suitable size and shape to accept an injector body 69 and nozzle 70 to be tested.

Fuel oil in the duct 46 also passes a second needle valve 48 co-operating with a seating 49. The needle valve 48 is controlled by a second threaded stem 50 similar to the stem 41 and is operable by a second knob 51 similar to the knob 42. The threaded stem 50 passes through a nut 52, similar to the nut 43. Fuel oil passing the valve 49 enters a duct 53 which is connected to the pipe 32 (shown dotted in Figure 4) leading to the pressure gauge 33.

When an injector is to be tested it is mounted in the tester and the pump, consisting of piston 15 operating in cylinder 14, is actuated by moving the lever 20 downwards, when fuel oil is forced into the block 29 and through the block to the pressure gauge and the injector. By screwing down the needle valve 39 to the appropriate degree a restriction is imposed on the flow of fuel oil from the pump such that the operator is compelled to operate the lever 20 slowly. Consequently the pressure at the injector rises slowly.

In order to carry out a "dry seat" test the pump pressure is raised to a level just below that at which the injector would normally open and the needle valve 39 is then screwed down completely, to close it. In

this way the pressure in the system is trapped and it is easy to note whether the needle seat leaks and allows a droplet of fuel oil to form on the end of the nozzle. If no such leakage takes place in a prescribed time then the needle valve 39 may be re-opened slightly while the pressure is restored to the original figure, by operation of the pump, and the needle valve 39 is again closed, the stop clock 36 being started at the same instant. The operator watches the pressure gauge until the pressure falls by a predetermined amount and then stops the clock 36. He then has an accurate record of the rate of leakage along the injector needle diameter, since this is related to the time which has been recorded.

To carry out the "buzz" test the restrictor valve 39 is set to impose a substantial restriction on flow. The operator is thus compelled to move the pump lever slowly and the rapid fluctuations of pressure at the injector do not cause jerky movement of the pump lever.

To set the injection pressure the restrictor valve 39 is set to an almost closed position and the pump is operated to raise the pressure up to the injection pressure. Since the pressure at the injector rises very slowly it is possible to see the exact pressure reading at which the injector needle lifts to allow injection, and appropriate adjustments are made to the injector spring to set the injecto the desired opening pressure. The pointer 44, in conjunction with the graduations 45, facilitate the accurate setting of the valve 39.

During all these operations the flow of fuel oil to and from the pressure gauge 33 may be controlled by operation of the needle valve 48 by means of the knob 51. For example, during the "dry seat" and leakage tests the needle valve 48 may be opened to such an extent that the pressure gauge follows the injector pressure instantly. During the "buzz" test the needle valve 48 is preferably closed because the Bourdon tube in the pressure gauge would not only be subjected to violent pressure fluctations which might cause damage to it, but its flexibility will give rise to pressure waves which may interfere with the test.

When the injector opening pressure is being tested the needle valve 48 is preferably set to an almost closed position so that the pressure gauge needle accurately follows the very slow rise in pressure but cannot follow the sudden drop in pressure when the injector needle opens. This not only helps to prevent damage to the pressure gauge but enables the operator to see more clearly the exact pressure at which the injector opens.

WHAT WE CLAIM IS:—

1. The provision in apparatus for testing injectors and injector nozzles of compression ignition internal combustion engines, said apparatus comprising a manually operable pump adapted to supply liquid under pressure through a duct to an injector to be tested, there being a pressure gauge connected to the duct to indicate the pressure applied to the injector, of an adjustable liquid-flow restrictor valve provided in a passage leading from the pump to the duct.

2. Apparatus for testing injectors and injector nozzles of compression ignition internal combustion engines comprising a manually operable pump, a pressure gauge, means to support an injector and nozzle to be tested, and two adjustable restrictor valves, one of the restrictor valves being connected between the pump and the injector nozzle and the other of the restrictor valves being connected between the injector nozzle and the pressure gauge.

3. Apparatus for testing injectors and injector nozzles of compresion ignition internal combustion engines comprising a base, a hand-operated pump mounted in the base, a casing on the base, a pressure gauge mounted on the casing, two manually operable restrictor valves in a valve block supported on the casing, a support for an injector and nozzle to be tested carried on the casing, a duct in the block communicating with one side of each of the restrictor valves, a pipe connecting the duct to the injector, a pipe connecting the pump to the other side of one of the restrictor valves and a further pipe connecting the pressure gauge to the other side of the other of the restrictor valves.

4. Apparatus as claimed in Claim 3 comprising a hood supported on the casing surrounding the injection nozzle when mounted for test.

5. Apparatus as claimed in Claim 4 comprising an extractor driven by an air turbine to remove spray from the hood.

6. Apparatus as claimed in Claim 4 or 5 comprising a lamp incorporated in the hood to illuminate the injection nozzle during test.

7. Apparatus as claimed in any one of Claims 1 to 6 comprising a pointer on the restrictor valve (Claim 1), or on at least one of the restrictor valves (Claims 2 to 6), cooperating with graduations whereby the setting of the or the one restrictor valve is indicated.

8. Apparatus as claimed in any one of Claims 3 to 7 comprising a cover over the apparatus and a stop-clock mounted on the cover for timing test carried out on the nozzle.

9. Apparatus for testing injectors and

injector nozzles of compression ignition internal combustion engines constructed and arranged substantially as herein described, with reference to and as illustrated in the accompanying drawings.

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Abingdon : Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1962.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2,
from which copies may be obtained.

910894 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

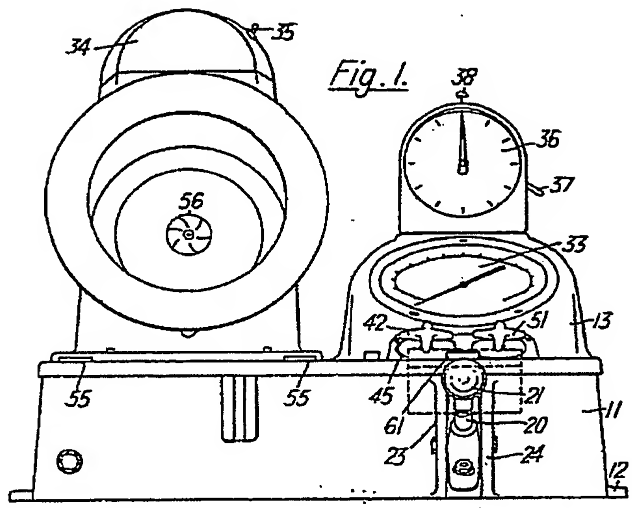
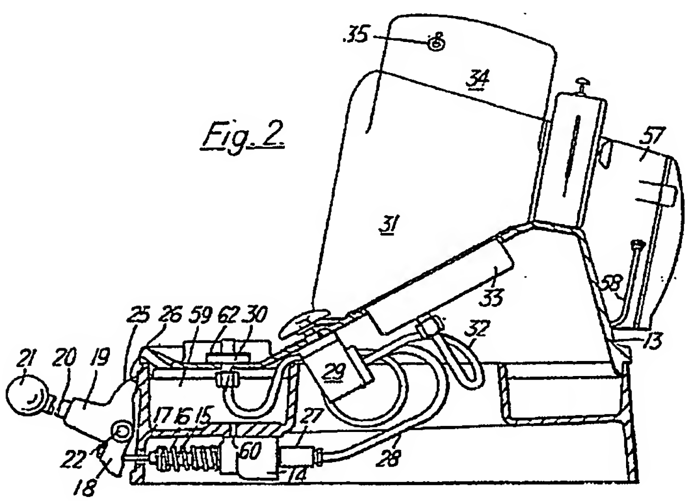


Fig. 1.

Fig. 2.



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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 2 & 3

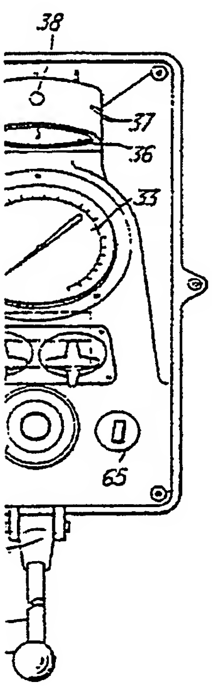


Fig.4.

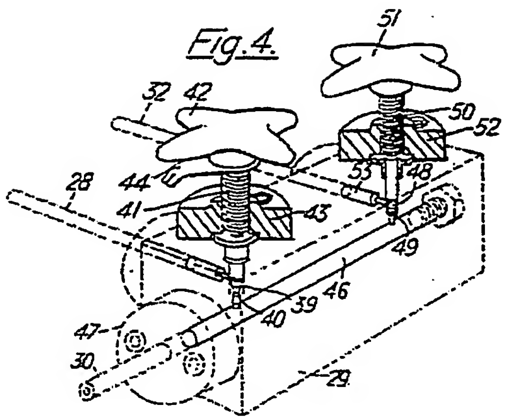
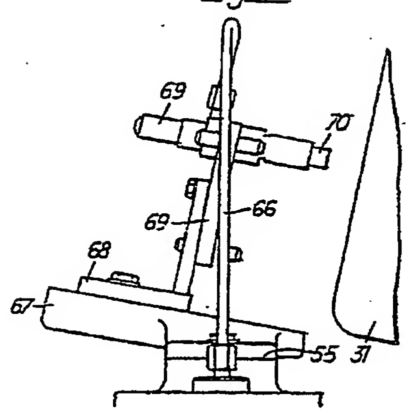


Fig.5.



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3 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheets 2 & 3

Fig. 3.

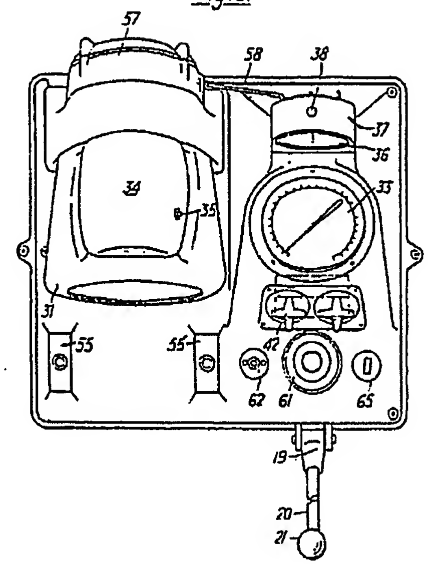

Fig. 4.

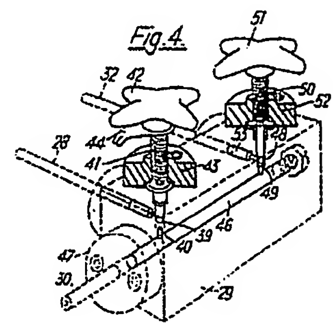

Fig. 5.

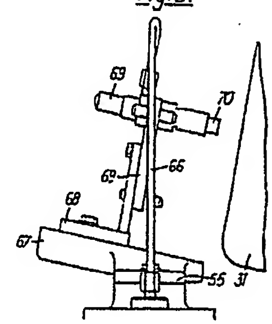

Fig. 3.